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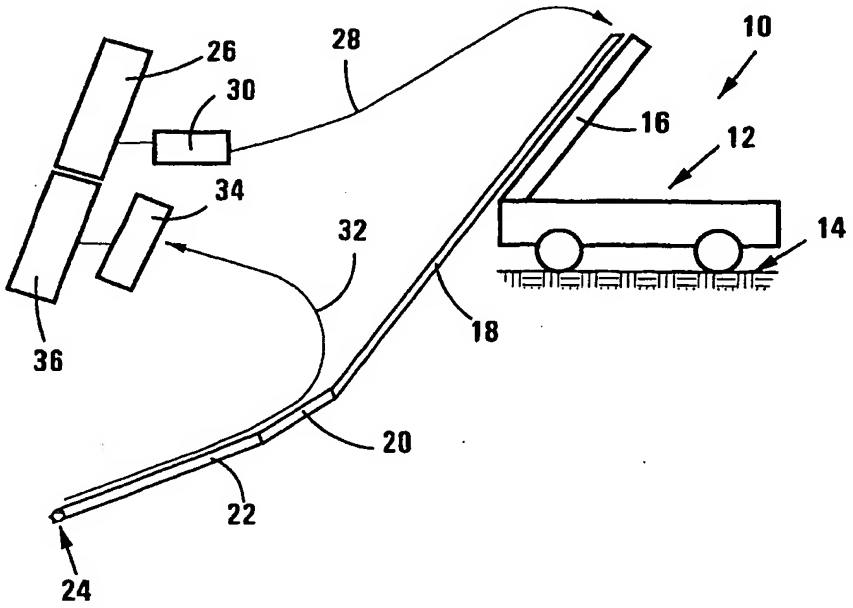

(57) Abstract

The invention provides a method of drilling and a drilling apparatus and drilling apparatus set. The apparatus includes a drill rig (12), a flexible string (18) of drill rods connected to the rig, a steerable downhole motor (22) connected to the string, a drill bit (24) connected to the motor (20) and monitoring means for detecting changes in the rate of movement of the drill bit. The method involves steering the motor to cause the bit to drill and at least partly curved borehole, the drilling being monitored to detect changes in the drilling which are indicative of discontinuities in sub–surface formations.

METHOD AND APPARATUS FOR EXPLORATION DRILLING

THIS INVENTION relates, broadly, to drilling. More particularly, the invention relates to a method and apparatus for drilling boreholes downwardly from the surface of the ground into underground- or sub-surface formations, the method and apparatus being suitable for, but not restricted to, exploration drilling for establishing the location of intrusions such as dolerite intrusions in ore bodies such as coal reserves, and being suitable also for drilling into underground ore bodies such as coal seams for the purpose of extracting or draining gases therefrom, for safety- or economic reasons.

According to one aspect of the invention there is provided a method of drilling which includes drilling an at least partly curved borehole using a drill bit rotatably driven by a steerable downhole motor at the lower end of a string of interconnected drill rods, the method including steering the motor to cause the drill bit to follow a desired path while it rotates, to form a borehole which is at least partly curved, preventing the drill rods and string from rotating while allowing at least some of the drill rods to flex into curved shapes, and monitoring the drilling to detect changes in the drilling which are indicative of discontinuities in sub-surface formations through which the drill bit passes.

It is expected that the invention will have substantial utility in exploring and recording the shapes or ore bodies or reserves such as coal

seams or mineral deposits to detect, and establish the positions, strikes and shapes of, intrusions such as dolerite intrusions therein. Ore bodies can be explored for displacements, faults, angles, strikes and to determine dimensions thereof such as their thicknesses. Naturally, however, the method and apparatus are not restricted to coal and dolerite and can be used, in general, to explore various sub-surface formations such as strata and intrusions or like geological occurrences therein such as displacements. Furthermore, the invention can, instead, be used for drilling of boreholes from the surface to intersect strata such as coal seams for the purpose of draining gases therefrom, for reasons of safety or economics. Thus, drilling can take place in specific zones, eg in or above coal seams or other gas sources for gas extraction as a product or gas drainage for increasing mining safety, either before mining is started or as it takes place. Naturally, the invention can be used for various combinations of the above purposes.

Monitoring the drilling may be intermittent but is preferably continuous and may be by means of a downhole measurement-while-drilling steering system, conveniently operated by an operator at a drill rig, which drill rig may be underground in a shaft but is typically on the surface, the steering system being of a type known in the art and capable of steering the drill bit by means of the motor and thus capable of drilling a curved borehole. With such steering systems it is possible to determine the shape of the borehole and the rate at which drilling is proceeding. Changes or discontinuities in the rate of drilling can thus be detected, and the locations of such changes or discontinuities can also be detected. Thus, in particular, the monitoring may be continuous, being by means of a downhole measurement-while-drilling steering

system which monitors the position and shape of the borehole and the rate of propagation of the borehole, to detect the curvature of the borehole where the drill bit is situated and to detect changes in the rate of propagation of the borehole, and to detect the locations of the drill bit when such changes take place, being the locations of discontinuities through which the drill bit passes and which give rise to said rate changes.

Instead or in addition, the monitoring may include pumping a drilling liquid, such as water, down the borehole to cause a return flow of the liquid to carry cuttings from the drill bit to the surface, and analyzing the cuttings at the surface. Thus, the cuttings can be analyzed and inspected to detect changes or discontinuities in the sub-surface formations being drilled and, in conjunction with the measurement-while-drilling system, can be used to establish the location and nature of such changes or discontinuities.

In accordance with the method of the invention a plurality of initially vertical or initially inclined boreholes can be drilled, in accordance with a desired or predetermined pattern and of desired or predetermined shapes which will be at least partly curved, at the site of an ore body such as a coal deposit or reserve, typically in the form of a coal seam or coal stratum having strata above and below the seam of materials different from the coal, and potentially having dolerite intrusions in the seam and displacements of the seam. The intrusions are typically associated with devolatilized coal adjacent the surface of the dolerite. A plurality of locations, in these boreholes, can be established of interfaces between coal, on the one hand, and dolerite or adjacent strata

of other materials, on the other hand. Plotting such locations in three dimensions allows the shape of a coal seam to be established, together with the shape and location of dolerite intrusions and seam displacements therein. Naturally, the more boreholes are drilled, the more detailed and accurate the plot. In other words, the method may include drilling a plurality of said boreholes at a drilling site, the boreholes being drilled in accordance with a known pattern and being drilled to be of known shapes, and using the locations of detected discontinuities to establish the shapes and locations of underground ore bodies and the shapes and locations of intrusions in the ore bodies.

In a refinement of the method, instead of drilling a plurality of boreholes with the intention of having them each intersect a coal/dolerite interface once, an original or mother borehole which has intersected a coal/dolerite interface can be used, by means of deflections therefrom, to intersect the interface at a plurality of positions. Thus, once a dolerite intrusion or displacement has been detected by a borehole, that borehole can be used as a mother hole and, upstream of the dolerite, one or more deflection boreholes can be used to branch therefrom, in the general direction of the dolerite, thereby increasing the number of locations of coal/dolerite interfaces detected, while using the mother hole relatively to reduce the total amount of drilling, compared with drilling without deflections. In particular, thus, least one borehole may be drilled which intersects a discontinuity in the sub-surface formation, that borehole then being used as a mother hole and the method including, upstream of the discontinuity in the mother hole, drilling at least one deflection borehole branching from the mother hole and propagating it alongside the mother hole in a direction towards the discontinuity.

According to another aspect of the invention there is provided a drilling apparatus for drilling boreholes downwardly from the surface of the ground into sub-surface formations, the apparatus including a drill rig, a string of drill rods having an upper end releasably connected to the drill rig, the rods of the string being interconnected in series to form the string, a steerable downhole motor releasably connected to a lower end of the string, and a drill bit releasably and drivingly connected to the motor, and monitoring means for detecting changes in the rate of movement of the drill bit which are indicative of discontinuities in sub-surface formations through which the drill bit passes, the string being flexible to permit it to pass along curved boreholes and the rods being releasably interconnected to permit the number of rods in the string to be varied.

The rods may be resiliently flexible, being of high tensile metal. The apparatus may include a drilling liquid supply associated with the drill rig and at least one pump connected to the supply for pumping liquid from the supply to a flow line defined by the string and along the flow line to the bit, the apparatus including a sump for receiving liquid returning to the surface from the bit along the borehole outside the string, and including cuttings separation means at the surface for separating water returned to the surface from the cuttings contained therein. The apparatus may include a downhole measurement-while-drilling steering system for steering the motor and bit and for simultaneously measuring the direction of travel and location of the motor and bit.

The invention extends to a drilling apparatus set for connecting a drilling apparatus set for connection together to provide an apparatus for drilling boreholes downwardly from the surface of the ground into sub-surface formations, the set including a drill rig for drilling boreholes by means of a drill bit at the lower end of a string of drill rods, at least one drill bit releasably connectable to a lower end of a string of drill rods, the string being flexible to permit it to pass along a curved borehole and having an upper end releasably connectable to the drill rig, a plurality of drill rods releasably interconnectable in series to form the string with an upper end releasably connectable to the drill rig and a lower end releasably connectable to the drill bit, a steerable downhole motor releasably connectable to the lower end of the string and releasably connectable to the bit, thereby to connect the bit releasably to the string, and monitoring means for detecting changes in the propagation rate of the borehole which are indicative of discontinuities in sub-surface formations through which the drill bit passes.

It will be appreciated that, in use, the drill rods of the set will be connected together to form the string, the upper end of which string will be connected to the steering system and motor, the motor in turn being connected to the drill bit, to form the apparatus of the present invention. As indicated above, the drill rods may be of high tensile material such as high tensile steel or alloy, to permit the string to flex, preferably resiliently, as it passes along a curved part of a borehole. The supply of drilling liquid may be water-based, and may be located at the surface or down a shaft, one or more pumps being provided at or adjacent the supply for pumping the drilling liquid down the flow line defined by the drill rods forming the string, to the drill bit, the drilling liquid, together

with cuttings, returning from the drill bit to the surface in the annulus between the string and the wall of the borehole. At the surface the cuttings separation means may feed separated cuttings to a dump for the cuttings.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 shows a schematic side elevation of an apparatus for exploration drilling in accordance with the present invention;

Figure 2 shows a schematic side elevation of a coal deposit with the apparatus of Figure 1 in use;

Figure 3 shows a plan view of a drilling pattern suitable for small-scale apparatus in accordance with the present invention;

Figure 4 shows a plan view of a drilling pattern suitable for medium-scale apparatus in accordance with the invention;

Figure 5 shows a plan view of a drilling pattern suitable for large-scale apparatus in accordance with the invention;

Figure 6 shows a plan view of a borehole with two deflections; and

Figure 7 shows a plan view of an actual drilling pattern, based on Figure 3, carried out in practice.

With reference first to Figure 1 of the drawings, reference numeral 10 generally designates apparatus, in accordance with the present invention for exploration drilling of coal deposit to detect the presence, location and shape of dolerite intrusions therein. The apparatus 10 comprises a drilling rig in the form of a wheeled vehicle 12 at the surface 14. The vehicle 12 has a mast 16 to which is shown connected the

upper end of a string 18 of resiliently flexible drill rods of high tensile steel.

The lower end of the string 18 is connected to a downhole measurement-while-drilling steering system 20, which system is in turn connected to a steerable downhole motor 22, the motor 22 in turn being shown connected to a drill bit 24. A drilling liquid sump 26 is shown connected by a flow line 28 provided with a pump 30 to the upper end of the string 18, a flow line 32 in turn being shown leading from the bit 24 to a cuttings separation unit 34 alongside a cuttings dump 36.

In Figure 2 a schematic sectional side elevation of strata containing a coal seam is generally designated 38. At the surface 14 the vehicle 12 is shown with the string 18 of drill rods extending from its mast 16, at an inclination to both the horizontal and vertical, down a borehole 39. The strata comprise an uppermost stratum 40 of weathered material, a group 42 of strata (undifferentiated in the drawing) below the stratum 40 and above a coal seam 44. A group 46 of strata (also undifferentiated) is shown below the seam 44 and, below the group 46, a dolerite layer or stratum 48. A dolerite intrusion 50 is shown intruding upwardly from the layer 48, through the groups 42 and 46 and seam 44, up to the stratum 40. The string 18 and its associated borehole (shown with a casing 52 in the stratum 40) extend downwardly through the stratum 40 and group 42 of strata, to intersect the seam 44 and intrusion 50, the lower end of the string 18 and borehole 39 being shown in the intrusion 50.

In Figure 3 a drilling pattern is generally designated 54, being in plan view in the form of a cross. The rig will be located centrally at 12, at the intersection of the limbs of the cross, and will drill four boreholes 39 in the direction of the arrows along the limbs of the cross. The pattern 54 of Figure 3 is suitable for small-scale apparatus 10 (see Figure 1) capable of drilling boreholes of about 600 m in length.

In Figure 4 the same numerals designate the same parts as in Figure 3, unless otherwise specified. In Figure 4, boreholes 56 are shown to be curved in plan view, instead of the straight (in plan view) boreholes 39 of Figure 3, and there are eight boreholes 56 instead of four. The pattern 54 of Figure 4 is suitable for medium-scale apparatus 10 (see Figure 1) capable of drilling boreholes of about 1200 m in length.

In Figure 5 in turn the same reference numerals are again used for the same parts as in Figures 3 and 4, unless otherwise specified. Figure 5 employs, in combination, the eight curved (in plan view) boreholes 56 of Figure 4, together with the four straight (in plan view) boreholes 39 of Figure 3, so that it has twelve boreholes 39, 56 in total. The pattern 54 of Figure 5 is suitable for large-scale apparatus 10 (see Figure 1) capable of drilling holes of more than 1800 m in length.

In Figure 6 part of a borehole pattern 54 is shown, comprising a mother borehole 39 with two deflection boreholes 58 branching therefrom. The point where each of the boreholes 39, 58 intersects a dolerite intrusion is designated by a block 60.

Finally, in Figure 7 an actual drilling pattern 54, based on Figure 3 and carried out in practice, is shown, the same reference numerals again showing the same parts, unless otherwise specified. Mother boreholes 39 are shown radiating out in a roughly cruciform pattern from the location of the rig at 12, some of the mother boreholes 39 being provided with deflection boreholes 58. On the pattern is superimposed a distance scale reading 500 m in opposite directions from the rig 12, along perpendicular axes 62.

With reference to the drawings, particularly Figures 1 and 2 thereof, the rig 12, at the surface 14, is used to drill a borehole 39 which may initially be vertical or inclined, an inclined borehole in fact being shown in Figure 2, corresponding to the inclined set-up of the apparatus 10 shown in Figure 11. The borehole 39, and the string 18 of drill rods in the bore-hole 39, are shown extending downwardly and from right to left from the mast 16 of the rig 12 through the casing 52 in the stratum 40 and then through the group 42 of strata and into the coal seam 44. The borehole is initially straight, but just before it enters the seam 44 it begins to curve upwardly and to the left to reduce its inclination to the horizontal and to become more nearly horizontal. Instead, the borehole can start to curve at the surface, with no initial straight portion. It is shown leaving the seam and entering the intrusion 50 at a position close to the lower end of the borehole 39. While the borehole is shown entering the intrusion 50 close to the bottom of the seam 44, it can instead enter the intrusion 50 close to the top of the seam 44 or close to the middle of the seam, and indeed can enter the intrusion 50 above or below the seam 44, if required.

As the borehole is drilled, the apparatus is monitored by the measurement-while-drilling steering system 20 and the steerable motor 22 is used to steer the bit 24 to follow the curved path illustrated for the lower part of the borehole 39, the steering being by an operator at the rig 12 at the surface 14. The monitoring by the system 20 is confirmed by inspection of cuttings brought to the surface in drilling liquid pumped from sump 26 by pump 30 along line 28 to the upper end of the string 18 and thence along a flow line defined in the rods making up the string 18, down the borehole 39 to the bit 24. At the lower end of the borehole 39 the liquid picks up cuttings from the bit 24 and carries them up to the surface along flow line 32, defined by the annulus between the string 18 and the wall of the borehole 39, to the separation unit 34 where they are separated from drilling liquid and dumped on the dump 36.

Changes in drilling rate, as monitored by the system 20 and as confirmed by inspection of cuttings separated by the unit 34, indicate the position of the interface where the drill bit 24 intersects the coal seam 44 from the group 42 of strata, and indicate also the interface where the drill bit 24 enters the intrusion 50 from the seam 44. Typically, the drilling rate will increase when the bit 24 enters the seam 44 and will suddenly decrease when the bit 24 enters the intrusion 50. Indeed, the bit 24 will usually be replaced by a different bit 24, suitable for dolerite, when the intrusion is intersected, a bit suitable for coal drilling being used initially. Naturally, the string 18 will be lengthened from time to time, as necessary, by adding drill rods thereto, and the method will typically involve casing the part of the borehole in the top stratum 40.

As the bit approaches the dolerite intrusion 50 it will typically pass through devolatilized coal adjacent the intrusion, and if the borehole is drilled through the intrusion to determine the thickness of the intrusion, the bit will pass through more devolatilized coal as it leaves the intrusion. The strike or inclination of the intrusion 50 can be determined by drilling one or more deflection boreholes 58 from the mother borehole 39 (Figure 6) to determine where the deflection boreholes intersect the dolerite intrusion, at a distance eg of about 100 m from the intersection of the mother borehole 39 with the dolerite.

Samples of cuttings can be used to confirm monitoring effected by the system 20, and also to determine the thickness of devolatilized coal adjacent the intrusion 50. Displacements of the seam 44, its thickness and its angle to the horizontal can be established by drilling a plurality of regularly or evenly spaced boreholes downwardly or upwardly through the seam 44 and into the groups 42 or 46 of strata respectively thereabove and thereunder. The holes used for this purpose can furthermore if desired be employed as mother boreholes, being supplemented by short deflection boreholes 58 at appropriate places. Similarly, the strike or inclination of a seam displacement can be determined by drilling boreholes in various directions, supplemented by appropriately located deflection boreholes branching therefrom.

The position of the drill bit can be monitored continuously by an operator who is steering the motor from the surface to obtain a borehole of any desired trajectory, ie curvature or shape. Samples can be collected continuously at the surface and the hardness of strata, seams

and intrusions can be monitored from the surface, all without the need for wedges or wedging equipment.

In a typical case the drill bit 24 will be steered along a straight(as shown) or curved inclined path downwardly from the surface 14 towards the seam 44. As it reaches the seam 14 it is steered along a curve until it is more or less horizontal and can proceed along the interior of the seam along a path in accordance with a chosen drilling pattern, for example as shown in Figures 3 - 5. As indicated above, drilling rates drop suddenly when intrusions are intersected, special bits being used to drill through the intrusions to determine intrusion thicknesses, while cutting samples are analyzed to measure devolatilized coal thicknesses. Dolerite intrusion strikes may be obtained by using deflection boreholes which are curved in plan view and which extend horizontally as shown in Figure 6 along curves such that the deflection boreholes 58 have intersections 60 with the dolerite at a distance D of eg about 100 m from the intersection of the mother borehole 39 with the dolerite.

It is an advantage of the invention, as described with reference to the drawings, that it can be used to explore and map coal deposits in a reliable three-dimensional fashion whereby the existence, positions and dimensions of up to 80% or more of the dolerite intrusions in a coal seam can be established, depending on the drilling patterns used and numbers of boreholes drilled. The drilling patterns described above with reference to Figures 3 - 5, taken with Figures 6 and 7, are intended in use to determine the locations and characteristics of at least 80% of the dolerite intrusions in the area explored, typically 85 - 95% thereof. While the method (and apparatus) of the invention have been described in the

context of exploration drilling using patterns of the type exemplified by Figures 3 - 7, it will further be appreciated that they can also be used in the drilling of one or more specific boreholes in predetermined respective directions, which are not associated together to form a drilling pattern.

While the invention has been described in the context of the drawings with particular reference to exploration drilling of a coal seam containing possible dolorite intrusions, it will be appreciated that the apparatus of Figure 1 can be used at the coal deposit of Figure 2, and indeed with the drilling patterns of Figures 3 - 6 or similar drilling patterns, for recovery or drainage of gas, such as methane or the like, from the coal deposit.

A plurality of boreholes can thus be drilled according to a desired or predetermined suitable pattern, for the extraction of methane from the coal deposit. This can be, for example, for the recovery of methane as a product, if this is economically feasible or desirable. Instead, the methane extraction can simply act as drainage thereof to waste, eg to be burnt at a stack, if this is desirable for safety reasons if the coal deposit is being mined or is about to be mined.

CLAIMS

1. A method of drilling which includes drilling an at least partly curved borehole using a drill bit rotatably driven by a steerable downhole motor at the lower end of a string of interconnected drill rods, the method including steering the motor to cause the drill bit to follow a desired path while it rotates, to form a borehole which is at least partly curved, preventing the drill rods and string from rotating while allowing at least some of the drill rods to flex into curved shapes, and monitoring the drilling to detect changes in the drilling which are indicative of discontinuities in sub-surface formations through which the drill bit passes.

2. A method as claimed in claim 1, in which the monitoring is continuous, being by means of a downhole measurement-while-drilling steering system which monitors the position and shape of the borehole and the rate of propagation of the borehole, to detect the curvature of the borehole where the drill bit is situated and to detect changes in the rate of propagation of the borehole, and to detect the locations of the drill bit when such changes take place, being the locations of discontinuities through which the drill bit passes and which give rise to said rate changes.

3. A method as claimed in claim 1 or claim 2, in which the monitoring includes pumping a drilling liquid down the borehole to cause a return flow of the liquid to carry cuttings from the drill bit to the surface, and analyzing the cuttings at the surface.

4. A method as claimed in any one of the preceding claims, which includes drilling a plurality of said boreholes at a drilling site, the boreholes being drilled in accordance with a known pattern and being drilled to be of known shapes, and using the locations of detected discontinuities to establish the shapes and locations of underground ore bodies and the shapes and locations of intrusions in the bodies.

5. A method as claimed in any one of the preceding claims, in which at least one borehole is drilled which intersects a discontinuity in the sub-surface formation, that borehole then being used as a mother hole and the method including, upstream of the discontinuity in the mother hole, drilling at least one deflection borehole branching from the mother hole and propagating it alongside the mother hole in a direction towards the discontinuity.

6. A drilling apparatus for drilling boreholes downwardly from the surface of the ground into sub-surface formations, the apparatus including a drill rig, a string of drill rods having an upper end releasably connected to the drill rig, the rods of the string being interconnected in series to form the string, a steerable downhole motor releasably connected to a lower end of the string, and a drill bit releasably and drivingly connected to the motor, and monitoring means for detecting changes in the rate of movement of the drill bit which are indicative of discontinuities in sub-surface formations through which the drill bit passes, the string being flexible to permit it to pass along curved boreholes and the rods being releasably interconnected to permit the number of rods in the string to be varied.

7. An apparatus as claimed in claim 6, in which the rods are resiliently flexible, being of high-tensile metal.

8. An apparatus as claimed in claim 6 or claim 7, which includes a drilling liquid supply associated with the drill rig and at least one pump connected to the supply for pumping liquid from the supply to a flow line defined by the string and along the flow line to the bit, the apparatus including a sump for receiving liquid returning to the surface from the bit along the borehole outside the string, and including cuttings separation means at the surface for separating water returned to the surface from the cuttings contained therein.

9. An apparatus as claimed in any one of claims 6 - 8 inclusive, which includes a downhole measurement-while-drilling steering system for steering the motor and bit and for simultaneously measuring the direction of travel and location of the motor and bit.

10. A drilling apparatus set for connection together to provide an apparatus for drilling boreholes downwardly from the surface of the ground into sub-surface formations, the set including a drill rig for drilling boreholes by means of a drill bit at the lower end of a string of drill rods, at least one drill bit releasably connectable to a lower end of a string of drill rods, the string being flexible to permit it to pass along a curved borehole and having an upper end releasably connectable to the drill rig, a plurality of drill rods releasably interconnectable in series to form the string with an upper end releasably connectable to the drill rig and a lower end releasably connectable to the drill bit, a steerable downhole motor releasably connectable to the lower end of the string and

releasably connectable to the bit, thereby to connect the bit releasably to the string, and monitoring means for detecting changes in the propagation rate of the borehole which are indicative of discontinuities in sub-surface formations through which the drill bit passes.

11. A method as claimed in claim 1, substantially as described and as illustrated herein.

12. An apparatus as claimed in claim 6 or claim 7, substantially as described and as illustrated herein.

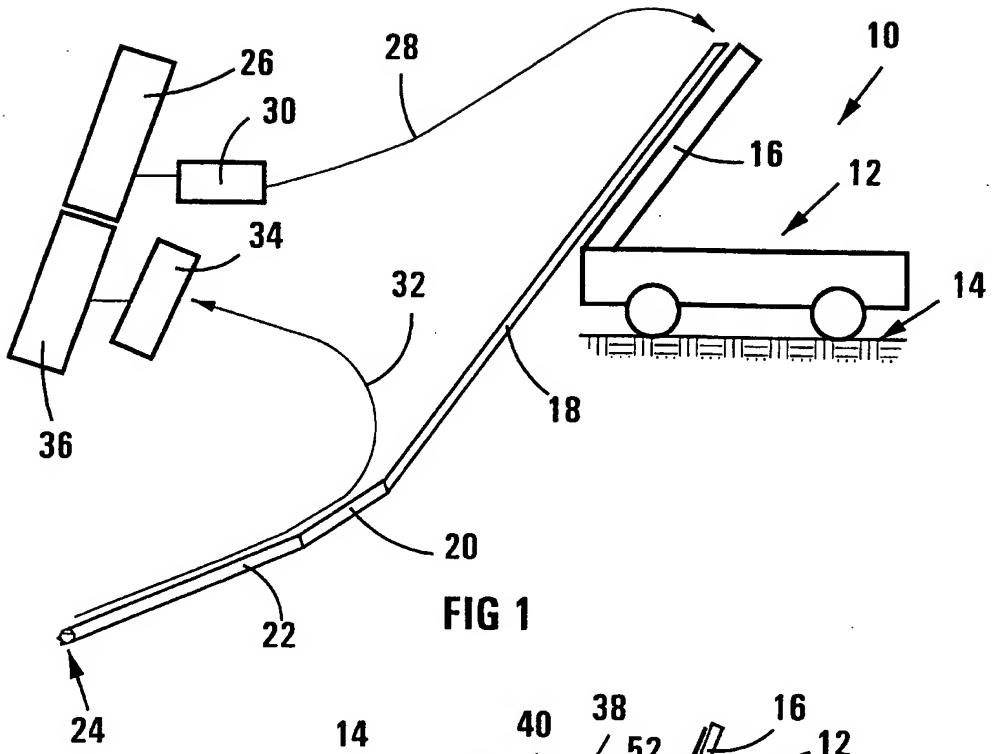
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FIG 1

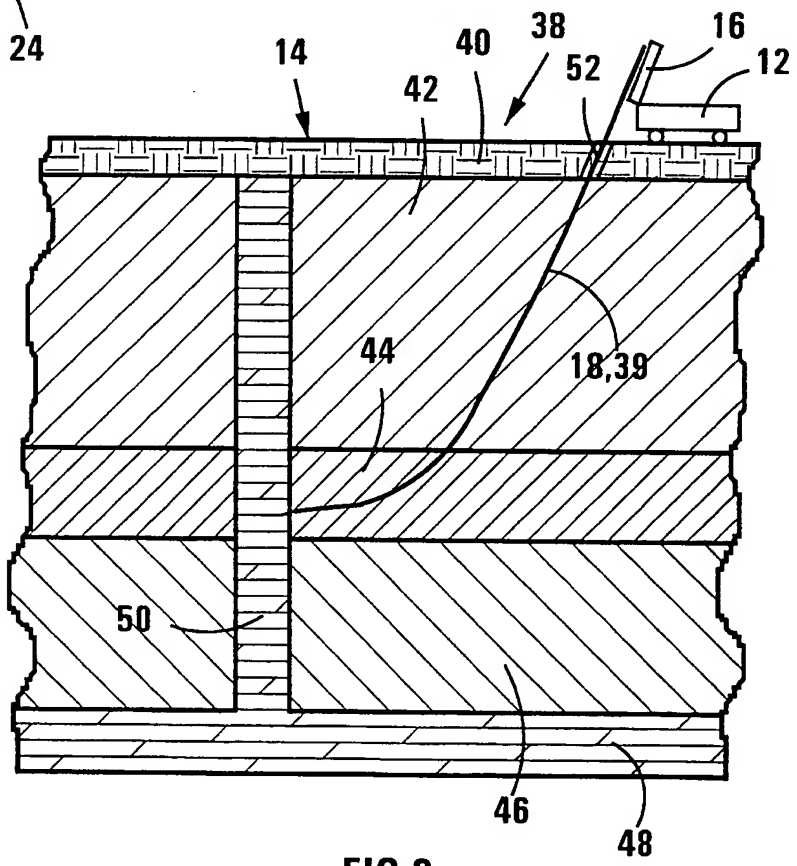
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FIG 2

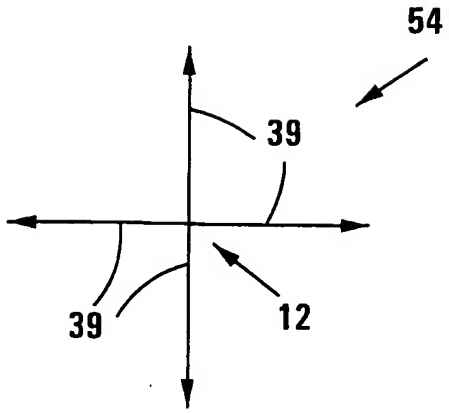

FIG 3

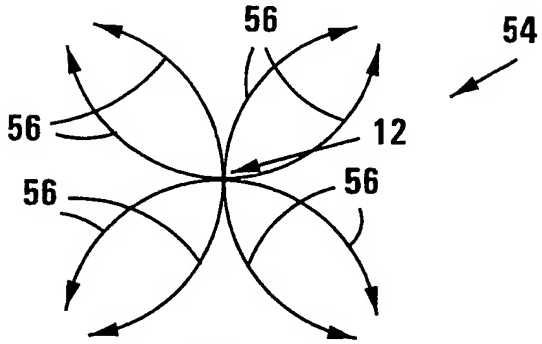

FIG 4

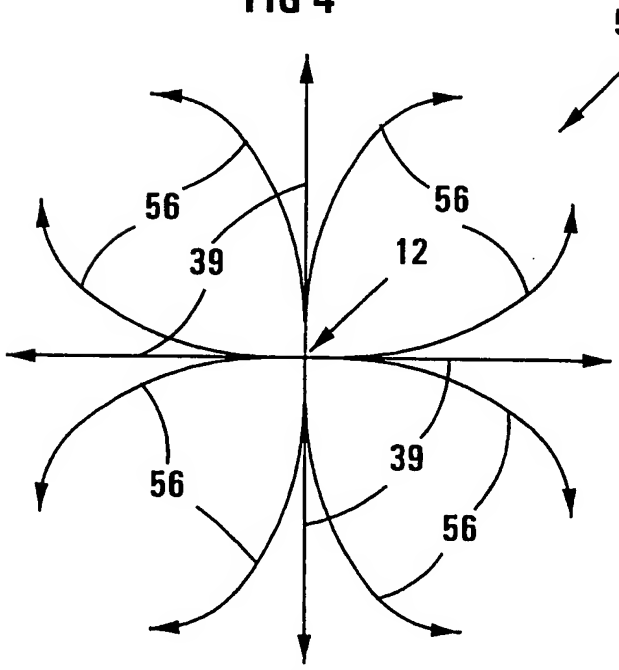

FIG 5

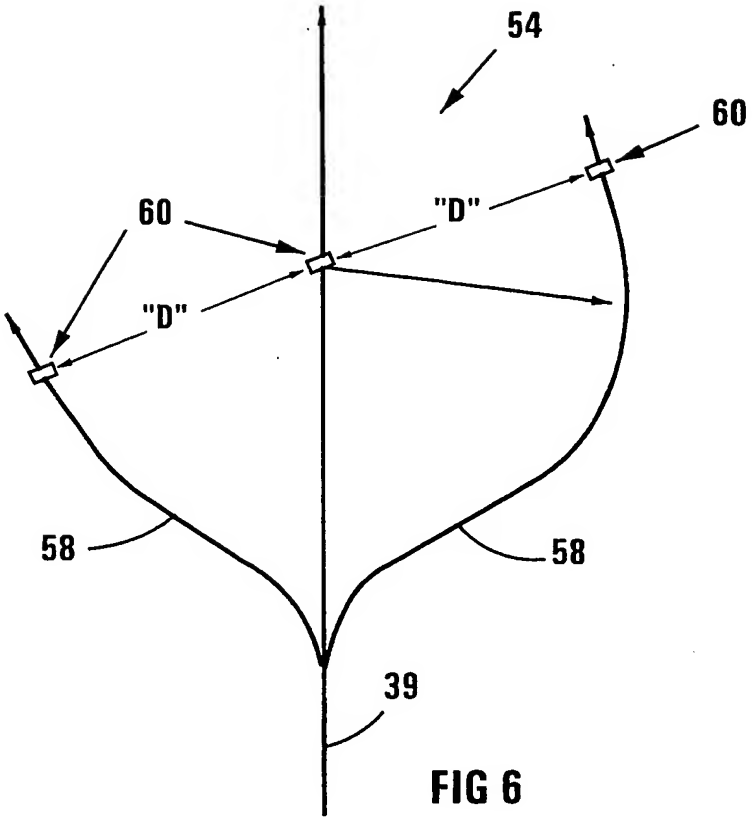
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FIG 6

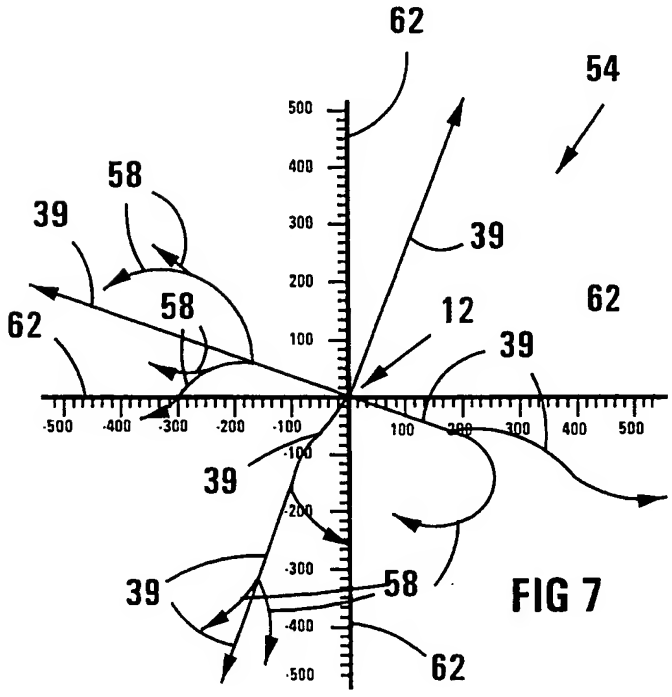
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FIG 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 99/01262

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: E21B 47/026, E21B 49/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0624706 A2 (BAKER-HUGHES INCORPORATED), 17 November 1994 (17.11.94), the whole document	1,2,4,6-10
Y		3,5
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Y	EP 0426232 A2 (SERVICES PETROLIERS SCHLUMBERGER), 8 May 1991 (08.05.91), page 3, line 32 - line 36, claim 16	3
	--	
Y	EP 0823534 A1 (ANADRILL INTERNATINAL, S.A. ET AL), 11 February 1998 (11.02.98), column 1 - column 3, figures 1-26	5
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 Sept 1999	04 11 1999
Name and mailing address of the International Searching Authority European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel(+31-70)340-2040, Tx 31 651 epo nl, Fax(+31-70)340-3016	Authorized officer Christer Bäknert / MR

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 99/01262

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0336491 A1 (ANADRILL INTERNATIONAL SA), 11 October 1989 (11.10.89), the whole document --	1-10
A	EP 0857855 A1 (HALLIBURTON ENERGY SERVICE, INC.), 12 August 1998 (12.08.98), the whole document -- --------	1-12

INTERNATIONAL SEARCH REPORT

Inte. .ional application No.
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Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
see extra sheet

2. [ ] Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

PCT Rule 6.2 (a) states that claims shall not, except where absolutely necessary, rely, in respect of the technical features of the invention, on references to the description or drawings. In particular, they shall not rely on such references as: "as described in part ... of the description," or "as illustrated in figure ... of the drawings."

Claims 11 and 12 do rely on such references as referred to in PCT Rule 6.2 (a). Hence, these claims are not allowable.

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/08/99

International application No.
PCT/IB 99/01262

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0624706 A2	17/11/94	CA 2123273 A	13/11/94
		NO 941769 A	14/11/94
		US 5325714 A	05/07/94
		US 5456106 A	10/10/95
		US 5679894 A	21/10/97
EP 0426232 A2	08/05/91	CA 2027496 A	29/04/91
		CA 2028053 A	29/04/91
		DE 69028596 D	00/00/00
		EP 0426231 A	08/05/91
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		GB 2237304 A	01/05/91
		GB 2237305 A,B	01/05/91
		US 5161409 A	10/11/92
		US 5360738 A	01/11/94
EP 0823534 A1	11/02/98	BR 9703805 A	11/08/98
		CA 2211883 A	30/01/98
		NO 973481 D	00/00/00
EP 0336491 A1	11/10/89	CA 1313862 A	23/02/93
		DE 6890324 U	26/11/92
		US 4876886 A	31/10/89
EP 0857855 A1	12/08/98	NONE	